MODELING HYDRAULIC FRACTURING OF DEEP SHALE GAS RESERVOIRS AT HPHT CONDITIONS

By

Mario Emad Saad Abdelmalek

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
Master of Science
in
Petroleum Engineering

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Title of Thesis:

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Key Words:

Hydraulic Fracturing; Shale Gas Reservoirs, Modeling; Deep; HPHT.

Summary:

A hydraulic fracturing model of shale gas reservoirs at deep HPHT conditions was built and adapted using programming codes and interface run by Visual Basic program which gives figures in Excel sheets. The model based on equations representing the effect of HPHT reservoir conditions on shale geomechanical properties and pressure losses in the tubing string for calculating fractures' dimensions and networks distribution. The design is based on tubing geometry, slurry properties, formation geomechanical properties under HPHT conditions and also on intensity of shale gas networks. Comparison to other models showed that when pressure losses inside long tubing reaching deep reservoirs and the effect of HPHT are taken into account, more accurate values for slurry pumped and future gas production are estimated from shale gas and less damage to surrounding formation is obtained. Finally, the effect of each factor on model results was discussed in detail.

DISCLAIMER

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name : Mario Emad Saad Abdelmalek Date : 17th November, 2018

Signature : Mario Emad Saad Abdelmalek

DEDICATION

This thesis is dedicated to my mother, Fayza Hakim Wahba. Without her support, I would not have been able to finish this work in my life time. So, I owe this thesis to her. She is the main reason why I have a master degree of petroleum engineering. Also, the thesis is dedicated to my father, Emad Saad who is the main reason why I have a bachelor degree of petroleum engineering.

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NOMENCLATURE

Alphabitic Letters

A	=	Area, ft^2
a	=	Calibration factor that is used to adjust the measured MSint
BHP	=	Total bottom hole pressure, psi
C	=	Concentration lbm/Mgal
CMHPG	=	Carboxymethyl hydroxyprobyl guar.
DP	=	Dual porosity.
Darcy	=	Author of Darcy law.
darcy	=	Unit of permeability.
d	=	Tubular diameter, in
E	=	Elasticity Modulus, psi
e	=	Aperture of the fracture "fracture width".
FC	=	Fractures conductivity, darcy.ft
G	=	Shear modulus, psi
g	=	Gravitional acceleration ft/s^2
H	=	Height, ft
HF	=	Hydraulic fracture intensity, Frac / m
ID	=	Dimensionless flow rate, dimensionless
K	=	Over all formation leak off coefficient, ft/ $min^{0.5}$
k	=	An adjustment, dimensionless factor for μ and E which is estimated to be $3.44x10^{-4}$
K_f	=	Fractures permeability, Darcy
KGD	=	Khristianovic-Geertsma-de. "name of the author who proposed KGD model for hydraulic fracturing"
L	=	Length, ft
M	=	Factor for proppant correction calculations, dimensionless
MS	=	Microseismic, frac/ ft
Nre	=	Reynold number, dimensionless
n',k'	=	Power law model coefficients, dimensionless
P	=	Pressure, psi
PKN	=	Perkins-Kern-Nordgren "name of the author who proposed PKN model for hydraulic fracturing"
Q	=	Flow rate, for slurry unit is bbl/min, for gas unit is SCF/day.
REV	=	Representative element volume.
S	=	Connection factor, dimensionless
TF	=	Treatment fluid
TOC	=	Total organic content

UFM	=	Unconventional fracture model
V	=	Volume, ft^3
v	=	Velocity, ft / s
VES	=	Viscoelastic surfactant.
W	=	Width, ft

Greek Letters

ρ	=	Density, ppg
σ	=	Horizontal stress (Sigma), psi
υ	=	Poisson's ratio, dimensionless
μ	=	Viscosity, cp
β	=	Formation volume factor, ft^3/SCF.

Sub-scripts

avg	=	Average
B	=	Bulk
e	=	reservoir drive.
f	=	Fracture
g	=	Gas
h	=	Hydrostatic
i	=	Injection
int	=	Intensity
opt	=	Optimum
p	=	Polymer
prop	=	propped width or volume.
r	=	Slurry to gel ratio.
sl	=	Slurry
wf	=	well flow.
X	=	X-Axis
Y	=	Y-Axis